DECLARATION

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[Title of the Invention] Semiconductor Laser Device and Method of Fabricating The Same

[Scope of Claim for Patent]

[Claim 1] A semiconductor laser device characterized in that a ridge portion having an upper surface of a first width is formed in a region of a predetermined width on a first nitride based semiconductor layer including a light emitting layer and containing at least one of indium, gallium, aluminum and boron; a current blocking layer having an opening of a second width smaller than said first width on the upper surface of said ridge portion is formed on said first nitride based semiconductor layer; and a second nitride based semiconductor layer containing at least one of indium, gallium, aluminum and boron is formed on said first nitride based semiconductor layer inside said opening.

[Claim 2] The semiconductor laser device as recited in claim 1, characterized in that said current blocking layer is composed of a nitride based semiconductor containing at least one of indium, gallium, aluminum and boron.

[Claim 3] The semiconductor laser device as recited in claim 1 or 2, characterized in that said first nitride based semiconductor layer comprises an n-type cladding layer, said light emitting layer, and a p-type cladding layer constituted by a flat portion and a ridge portion.

[Claim 4] A method of fabricating a semiconductor laser device, characterized by comprising the steps of:

forming a first nitride based semiconductor layer including a light emitting layer and containing at least one of indium, gallium, aluminum and boron;

forming a ridge portion having an upper surface of a first width in a region of a predetermined width on said first nitride based semiconductor layer;

forming on said first nitride based semiconductor layer a current blocking layer having an opening of a second width smaller than said first width on the upper surface of said ridge portion; and

forming a second nitride based semiconductor layer containing at least one of indium, gallium, aluminum and boron on said first nitride based semiconductor layer inside said opening.

[Claim 5] The method of fabricating the semiconductor laser device as recited in claim 4, characterized in that

said current blocking layer is composed of a nitride based semiconductor containing at least one of indium, gallium, aluminum and boron, and

the step of forming said current blocking layer comprises the steps of

forming a striped insulating film on the upper surface of said ridge portion, and

forming said current blocking layer extending to a region, excluding the region having said second width, on the upper surface of said ridge portion from a region on said first nitride based semiconductor layer on both sides of said ridge portion by using a transverse growth technique.

[Claim 6] The method of fabricating the semiconductor laser device as recited in claim 4 or 5, characterized in that

the step of forming said first nitride based semiconductor layer comprises the step of forming an n-type cladding layer, said light emitting layer, and a p-type cladding layer in this order, and

the step of forming said ridge portion comprises the step of etching said p-type cladding layer, except in a region having said first width of said p-type cladding layer.

[Detailed Description of the Invention]

[0001]

[Technical Field to which the Invention Belongs]

The present invention relates to semiconductor laser devices having compound semiconductor layers composed of III-V group nitride based semiconductors (hereinafter referred to as nitride based semiconductors) such as BN (boron nitride), GaN (gallium nitride), AlN (aluminum nitride) or InN (indium nitride) or their mixed crystal and methods of fabricating the same.

[0002]

[Conventional Art]

As light sources of optical disk systems for recording and reproducing optical disks, semiconductor laser devices have been employed. Particularly, expectations have been growing that nitride based semiconductor laser devices such as GaN based semiconductor laser devices are used as light sources for high-density optical disk systems such as new generation digital video disks.

[0003]

Fig. 5 is a schematic sectional view showing an example of a GaN based semiconductor laser device.

In a semiconductor laser device 110 shown in Fig. 5, an AlGaN buffer layer 32, an undoped GaN layer 33, an n-GaN layer 34, an n-AlGaN cladding layer 35, a multi quantum well light emitting layer (hereinafter referred to as an MQW light emitting layer) 36, a p-AlGaN cladding layer 37, a p-first GaN cap layer 38, a current blocking layer 39 composed of n-AlGaN, and a p-second GaN cap layer 40 are stacked in this order on a sapphire substrate 31.

[0004]

The semiconductor laser device 110 has a ridge waveguide structure. A ridge portion is constituted by the p-AlGaN cladding layer 37 and the p-first GaN cap layer 38. A partial region from the p-second GaN cap layer 40 to the n-GaN layer 34 is etched, so that an n electrode 50 is formed

on the exposed n-GaN layer 34. On the other hand, a p electrode 51 is formed on the p-second GaN cap layer 40.

[0005]

In the semiconductor laser device 110, a current injected from the p electrode 51 is narrowed by the current blocking layer 39. Therefore, a striped region in the ridge portion becomes a current injection region, as indicated by arrows in Fig. 5. Consequently, a region 41 at the center of the MQW light emitting layer 36 emits light. Further, the refractive index in the current blocking layer 39 composed of n-AlGaN is set to be lower than the refractive index in the p-AlGaN cladding layer 37 in the ridge portion, whereby the effective refractive index in a region 41 at the center of the MQW light emitting layer 36 is higher than the effective refractive index in a region on both sides thereof. Consequently, light is confined in the region 41 at the center of the MQW light emitting layer 36. Transverse mode control is thus carried out in the semiconductor laser device 110.

[0006]

In the semiconductor laser device 110, low-noise characteristics are required at the time of reproducing the optical disk. In the semiconductor laser device 110 lasing in a single mode, however, laser light has strong coherence, so that noise occurs by light returned from the optical disk. Therefore, a semiconductor laser device in which a region

having saturable light absorbing characteristics (hereinafter referred to as a saturable light absorbing region) is formed by forming a low current injection region in the MQW light emitting layer 36 has been proposed. In the semiconductor laser device, low-noise characteristics are achieved by subjecting the laser light to self-sustained pulsation.

[0007]

Figs. 6 (a) and 6 (b) are schematic sectional views showing an example of a semiconductor laser device having low-noise characteristics.

[0008]

A semiconductor laser device 120 shown in Fig. 6 (a) has the same structure as the semiconductor laser device 110 shown in Fig. 5 except for the following.

[0009]

In the semiconductor laser device 120, when a ridge portion is formed by etching, steps are further formed in a p-AlGaN cladding layer 37 so that the width W_3 of the upper step is smaller than the width W_4 of the lower step. Consequently, a striped region having the width W_3 in the ridge portion becomes a current injection region as indicated by arrows in Fig. 6 (a), and a saturable light absorbing region 42 is formed on both sides of the current injection region in an MQW light emitting layer 36. As a result, laser

light is subjected to self-sustained pulsation.

[0010]

On the other hand, a semiconductor laser device 130 shown in Fig. 6 (b) has the same structure as the semiconductor laser device 110 shown in Fig.5 except for the following.

[0011]

In the semiconductor laser device 130, the etching depth in forming a ridge portion is controlled, to increase the thickness d of a p-AlGaN cladding layer 37. Consequently, a striped region in the ridge portion becomes a current injection region, as indicated by arrows in Fig.6 (b). By increasing the thickness d of the p-AlGaN cladding layer 37, the difference in the effective refractive index in the horizontal direction is decreased in an MQW light emitting layer 36. Accordingly, light oozes out in the horizontal direction into a region, excluding a region under the ridge portion, of the MQW light emitting layer 36. Consequently, a saturable light absorbing region 42 is formed on both sides of the current injection region in the MQW light emitting layer 36. As a result, laser light is subjected to self-sustained pulsation.

[0012]

[Problems to Be Solved by the Invention]

A nitride based semiconductor layer such as a GaN based

semiconductor layer is chemically stable. Therefore, the nitride based semiconductor layer cannot be patterned by wet etching, unlike a GaAs based semiconductor layer used for the conventional semiconductor laser device emitting red light or infrared light, and must be patterned by dry etching such as RIE (Reactive Ion Etching) or RIBE (Reactive Ion Beam Etching). In such dry etching, selective etching cannot be performed. Accordingly, it is difficult to control the etching with high precision. Consequently, it is difficult to accurately form the structures of the above-mentioned semiconductor laser devices 120 and 130.

[0013]

An object of the present invention is to provide a semiconductor laser device having low-noise characteristics which can be easily fabricated and a method of fabricating the same.

[0014]

[Means for Solving the Problems and Effects of the Invention]

In a semiconductor laser device according to the present invention, a ridge portion having an upper surface of a first width is formed in a region of a predetermined width on a first nitride based semiconductor layer including a light emitting layer and containing at least one of indium, gallium, aluminum and boron; a current blocking layer having

an opening of a second width smaller than the first width on the upper surface of the ridge portion is formed on the first nitride based semiconductor layer; and a second nitride based semiconductor layer containing at least one of indium, gallium, aluminum and boron is formed on the first nitride based semiconductor layer inside the opening.

[0015]

In the semiconductor laser device according to the present invention, the first nitride based semiconductor layer is etched, and the ridge portion having the upper surface of the first width is formed. The current blocking layer is formed on a region from a side surface of the ridge portion to the upper surface thereof. In the current blocking layer, the opening having the second width is formed on a predetermined region on the upper surface of the ridge portion. The width (the second width) of the opening is smaller than the width (the first width) of the upper surface of the ridge portion.

[0016]

In the above semiconductor laser device, a current injected into the second nitride based semiconductor layer is narrowed by the current blocking layer. Consequently, the current is injected into the first nitride based semiconductor layer under the opening having the second width, whereby an optical waveguide is formed in the light

emitting layer below the opening. In this case, the width (the second width) of a current injection region under the opening is smaller than the width (the first width) of the upper surface of the ridge portion. In the light emitting layer below the ridge portion, therefore, a region which emits light other than the current injection region, that is, a region having saturable light absorbing characteristics (a saturable light absorbing region) is formed. Consequently, laser light can be subjected to self-sustained pulsation. Therefore, a semiconductor laser device having low-noise characteristics is obtained.

[0017]

In the above-mentioned semiconductor laser device, the current blocking layer is formed in a region, excluding the region having the second width, on the upper surface of the ridge portion, so that the region having saturable light absorbing characteristics is formed in the light emitting layer. In the semiconductor laser device, the necessity of etching for forming the saturable light absorbing region is thus eliminated. Therefore, a semiconductor laser device having low-noise characteristics is easily obtained.

[0018]

The current blocking layer may be composed of a nitride based semiconductor containing at least one of indium, gallium, aluminum and boron.

[0019]

The current blocking layer composed of the above-mentioned material can be grown in the transverse direction in the region, excluding the opening, on the upper surface of the ridge portion by being grown under predetermined growth conditions. Consequently, the current blocking layer having the opening having the second width is easily formed. The current injected into the second nitride based semiconductor layer is narrowed by the current blocking layer thus formed. Consequently, the region under the opening having the second width smaller than the first width of the upper surface of the ridge portion becomes a current injection region in the first nitride based semiconductor layer. Further, light is confined horizontally in the light emitting layer, so that transverse mode control can be carried out.

[0020]

The first nitride based semiconductor layer may comprise an n-type cladding layer, the light emitting layer, and a p-type cladding layer constituted by a flat portion and a ridge portion.

[0021]

In this case, it is difficult to increase the hole concentrations in the p-type cladding layer of the first nitride based semiconductor layer. Accordingly, the p-type

cladding layer has a high resistance. In the p-type cladding layer having a high resistance, the injected current is injected into the region under the opening narrower than the upper surface of the ridge portion without being widened. Consequently, the width of the current injection region is smaller than the width of the upper surface of the ridge portion.

[0022]

A method of fabricating a semiconductor laser device according to the present invention comprises the steps of forming a first nitride based semiconductor layer including a light emitting layer and containing at least one of indium, gallium, aluminum and boron; forming a ridge portion having an upper surface of a first width in a region of a predetermined width on the first nitride based semiconductor layer; forming on the first nitride based semiconductor layer a current blocking layer having an opening of a second width smaller than the first width on the upper surface of the ridge portion; and forming a second nitride based semiconductor layer containing at least one of indium, gallium, aluminum and boron on the first nitride based semiconductor layer inside the opening.

[0023]

In the method of fabricating the semiconductor laser device according to the present invention, the current

blocking layer having the opening having the second width smaller than the first width is formed on the upper surface of the ridge portion having the first width. In the fabricated semiconductor laser device, therefore, a current injected into the second nitride based semiconductor layer is narrowed by the current blocking layer. Consequently, a current injection region is formed in a region of the first nitride based semiconductor layer under the opening having the second width smaller than the width of the upper surface of the ridge portion, and an optical waveguide is formed in the light emitting layer below the opening. In this case, the width (the second width) of the current injection region is smaller than the width (the first width) of the upper surface of the ridge portion. In the light emitting layer below the ridge portion, therefore, a region which emits light other than the current injection region, that is, a region having saturable light absorbing characteristics is formed. Consequently, laser light can be subjected to self-sustained pulsation. Therefore, it is possible to fabricate a semiconductor laser device having low-noise characteristics.

[0024]

In the above-mentioned semiconductor laser device, the saturable light absorbing region is formed in the light emitting layer by not etching but growing the current

blocking layer in a region, excluding the region having the second width, on the upper surface of the ridge portion. Consequently, it is possible to easily fabricate a semiconductor laser device having low-noise characteristics.

[0025]

The current blocking layer may be composed of a nitride based semiconductor containing at least one of indium, gallium, aluminum and boron, and the step of forming the current blocking layer may comprise the steps of forming a striped insulating film on the upper surface of the ridge portion, and forming the current blocking layer extending to a region, excluding the region having the second width, on the upper surface of the ridge portion from a region on the first nitride based semiconductor layer on both sides of the ridge portion by using a transverse growth technique.

[0026]

In this case, the striped insulating film is formed on the upper surface of the ridge portion, and the current blocking layer having the opening is formed on the striped insulating film by using a transverse growth technique. The current blocking layer composed of the above-mentioned material can be easily grown in the transverse direction on the striped insulating film by being grown under predetermined conditions. Consequently, it is possible to

easily form the current blocking layer having the opening having the second width smaller than the width of the upper surface of the ridge portion. The current blocking layer is formed in the above-mentioned manner, thereby making it possible to narrow a current injected into the second nitride based semiconductor layer and to take a region under the opening narrower than the upper surface of the ridge portion as a current injection region in the first nitride based semiconductor layer. Further, light is confined horizontally in the light emitting layer, so that transverse mode control can be carried out.

[0027]

The step of forming the first nitride based semiconductor layer may comprise the step of forming an n-type cladding layer, the light emitting layer, and a p-type cladding layer in this order, and the step of forming the ridge portion may comprise the step of etching the p-type cladding layer, except in a region having the first width of the p-type cladding layer.

[0028]

In this case, the ridge portion is formed in the p-type cladding layer in the first nitride based semiconductor laser by etching. It is difficult to increase the hole concentration in the p-type cladding layer composed of a nitride based semiconductor, so that the p-type cladding

layer has a high resistance. In the p-type cladding layer having a high resistance, a current is injected into the region under the opening having the second width smaller than the width of the upper surface of the ridge portion without being widened. Consequently, it is possible to make the current injection region narrower than the ridge portion.

[0029]

[Embodiment of the Invention]

Fig. 1 is a schematic sectional view showing an example of a GaN based semiconductor laser device in an embodiment of the present invention.

[0030]

In a semiconductor laser device 100 shown in Fig. 1, an AlGaN buffer layer 2 having a thickness of 300 Å, an undoped GaN layer 3 having a thickness of 2 μm, an n-GaN layer 4 having a thickness of 3 μm, an n-AlGaN cladding layer 5 having a thickness of 0.7 μm, an MQW light emitting layer 6, a p-AlGaN cladding layer 7 having a thickness of 0.7 μm, a p-first GaN cap layer 8 having a thickness of 0.2 μm, a current blocking layer 9 having a thickness of 0.5 to 1.0 μm composed of n-AlGaN, and a p-second GaN cap layer 10 having a thickness of 0.5 to 1.0 μm are stacked in this order on the c(0001) plane of a sapphire substrate 1.

[0031]

In this case, Si is used as an n-type dopant, and Mg

is used as a p-type dopant.

[0032]

The MQW light emitting layer 6 has a multi quantum well structure obtained by alternately stacking six quantum barrier layers having a thickness of 60Å composed of n-$In_{0.03}Ga_{0.97}N$ and five quantum well layers having a thickness of 30 Å composed of $In_{0.18}Ga_{0.82}N$.

[0033]

The semiconductor laser device 100 has a ridge waveguide structure. A ridge portion having an upper surface of a width W_1 is constituted by the p-first GaN cap layer 8 and the p-AlGaN cladding layer 7.

[0034]

A partial region from the p-second GaN cap layer 10 to the n-GaN layer 4 is etched, so that an n electrode 50 is formed on the exposed n-GaN layer 4. Further, a p electrode 51 is formed on the p-second GaN cap layer 10.

[0035]

In the semiconductor laser device 100, a current injected from the p electrode 51 is narrowed by the current blocking layer 9. The refractive index in the current blocking layer 9 is set to a refractive index lower than the refractive index in the p-AlGaN cladding layer 7. Accordingly, the effective refractive index in a region 21 at the center of the MQW light emitting layer 6 is made higher

than the effective refractive index in a region on both sides thereof. Consequently, light is confined in the region 21 having a width W_1 at the center of the MQW light emitting layer 6, so that transverse mode control is carried out. A semiconductor laser device 100 having a real refractive guided structure is thus realized. In the GaN based semiconductor laser device 100, it is difficult to increase the hole concentrations in the p-type semiconductor layers 7, 8, and 10. Accordingly, the narrowed current is injected into the p-type semiconductor layers 7 and 8 below the current blocking layer 9 without being widened. Consequently, a striped region having a width W_2 under the opening of the current blocking layer 9 becomes a current injection region, as indicated by arrows in Fig. 1. In this case, the width W_2 of the current injection region is smaller than the width W_1 of the upper surface of the ridge portion ($W_1 > W_2$). In the light emitting region 21 in the MQW light emitting layer 6, a saturable light absorbing region 20 is formed on both sides of the current injection region. Accordingly, laser light is subjected to self-sustained pulsation. As a result, the width of a longitudinal mode spectrum of the laser light is increased so that the coherence of the laser light is decreased. Accordingly, the semiconductor laser device 100 is not easily subjected to noise.

[0036]

Fig. 2 is a diagram showing the ratio of the width W_1 of the upper surface of the ridge portion to the width W_2 of the opening of the current blocking layer 9 and the coherence (γ value) in the semiconductor laser device 100.

[0037]

As shown in Fig. 2, when the width W_1 of the upper surface of the ridge portion is 1 to 6 μm, the width W_2 of the opening is preferably 0.8 to 5.8 μm. When the ratio of W_1 to W_2 (W_2/W_1) is 0.1 to 0.95, the saturable light absorbing region is formed in the semiconductor laser device 100, thereby making self-sustained pulsation possible. Consequently, the coherence (γ value) in the semiconductor laser device 100 is not more than 0.5, so that low-noise characteristics are achieved. Further, when the ratio of W_1 to W_2 is 0.1 to 0.8, the coherence (γ value) in the semiconductor laser device 100 is the lowest, thereby making stable self-sustained pulsation possible.

[0038]

The Al composition ratio of the current blocking layer 9 composed of n-AlGaN is set to not less than the Al composition ratio of the p-AlGaN cladding layer 7. Consequently, the refractive index in the current blocking layer 9 is smaller than the refractive index in the p-AlGaN cladding layer 7 in the ridge portion. In order not to decrease the crystallizability of the current blocking layer

9, it is preferable that the Al composition ratio is slightly lower. Consequently, the Al composition ratio of the current blocking layer 9 is set to 0.12 to 0.20, for example.

[0039]

Although in the semiconductor laser device 100, Si is injected as n-type impurities into the current blocking layer 9, Zn may be injected as impurities in addition to Si. In this case, Zn has a high resistance. Accordingly, a current is narrowed in the current blocking layer 9 in which Zn has been injected.

[0040]

Description is now made of a method of fabricating the semiconductor laser device 100.

Figs. 3 and 4 are schematic sectional views showing the steps of fabricating the semiconductor laser device 100.

[0041]

As shown in Fig. 3 (a), an AlGaN buffer layer 2, an undoped GaN layer 3, an n-GaN layer 4, an n-AlGaN cladding layer 5, an MQW light emitting layer 6, a p-AlGaN cladding layer 7, and a p-first GaN cap layer 8 are grown in this order on a sapphire substrate 1 by metal organic chemical vapor deposition (MOCVD). The respective substrate temperatures at the time of growing the layers 2 to 8 in this case are as shown in Table 1.

[0042]

Table 1

	Substrate Temperature at the Time of Growth (°C)
AlGaN Buffer Layer 2	600
GaN Layer 3	1050
n-GaN Layer 4	1050
n-AlGaN Cladding Layer 5	1050
MQW Light Emitting Layer 6	800
p-AlGaN Cladding Layer 7	1050
p-First GaN Cap Layer 8	1050

[0043]

As shown in Fig. 3 (b), etching is then performed by RIE using chlorine, to form a ridge portion having an upper surface having a width W_1. Further, an SiO_2 film 30 is formed on the p-first GaN cap layer 8 in the ridge portion.

[0044]

As shown in Fig. 3 (c), a current blocking layer 9 composed of n-AlGaN is then grown on a region from a side surface to the upper surface of the ridge portion. In this case, the current blocking layer 9 is grown on the SiO_2 film 30, except in a region having a width W_2, by a transverse growth technique. Consequently, the current blocking layer 9 having a striped opening having a width W_2 is formed on the SiO_2 film 30.

[0045]

The substrate temperature at the time of growing the current blocking layer 9 is set to 1000 to 1100°C, and other growth conditions, for example, material gas flow rate and growth time are set such that the current blocking layer 9 is easily grown in the transverse direction on the SiO_2 film 30. Further, the current blocking layer 9 must be selectively grown on a region, excluding the opening, on the SiO_2 film 30. Therefore, it is preferable that the current blocking layer 9 is grown under reduced pressure.

[0046]

After the current blocking layer 9 is thus grown, the SiO_2 film 30 is removed by a hydrofluoric acid based etchant.

[0047]

As shown in Fig. 4 (d), a p-second GaN cap layer 10 is then grown on the p-first GaN cap layer 8 inside the opening and the current blocking layer 9. The substrate temperature at the time of growth in this case is set to 1050°C.

[0048]

Furthermore, as shown in Fig. 4 (e), a partial region from the p-second GaN cap layer 10 to the n-GaN layer 4 is etched, to expose an electrode forming region of the n-GaN layer 4.

[0049]

Finally, as shown in Fig. 4 (f), an n electrode 50 is

formed on the exposed n-GaN layer 4, and a p electrode 51 is formed on the p-second GaN cap layer 10.

[0050]

As described in the foregoing, in the method of fabricating the semiconductor laser device, the width W_2 of the current injection region is made smaller than the width W_1 of the ridge portion by not etching but selectively growing the current blocking layer 9 by using a transverse growth technique, to form a saturable light absorbing region 20. Even in the GaN based semiconductor laser device 100 in which it is difficult to control etching with high precision, therefore, it is possible to easily form the saturable light absorbing region 20. Consequently, it is possible to easily fabricate the semiconductor laser device 100 having low-noise characteristics.

[0051]

Although in the above-mentioned embodiment, description was made of a case where the current blocking layer 9 is composed of n-AlGaN, the current blocking layer 9 may be composed of other materials.

[0052]

For example, the current blocking layer 9 may be composed of InGaN in which Si or Zn has been injected as impurities. The In composition of the current blocking layer 9 composed of InGaN is approximately the same as or not less

than that of the quantum well layer in the MQW light emitting layer 6, for example, 0.10 to 0.15. When the current blocking layer 9 is formed, light emitted in the region of the MQW light emitting layer 6 below the current blocking layer 9 is absorbed by the current blocking layer 9. Accordingly, the light is concentrated on the region 21 having the width W_1 at the center of the MQW light emitting layer 6, so that transverse mode control is carried out. A semiconductor laser device 100 having a loss guided structure is thus realized. Also in this case, the current blocking layer 9 is grown in the transverse direction on the SiO_2 film 30, thereby forming a current injection region having a width W_2. The substrate temperature at the time of growing the current blocking layer 9 composed of InGaN is set to 700 to 800°C.

[0053]

The current blocking layer 9 may be composed of GaN in which Si or Zn has been injected as impurities. Alternatively, the current blocking layer 9 may be a current blocking layer 9 in which Si or Zn has been injected as impurities into AlGaN having a lower Al composition ratio than that of the AlGaN cladding layer. Also in this case, the current blocking layer 9 is grown in the transverse direction on the SiO_2 film 30, thereby forming a current injection region having a width W_2. The substrate temperature in this case is set to 1000 to 1100°C.

[0054]

Furthermore, the current blocking layer 9 may be formed by stacking layers having different compositions. For example, an AlGaN layer and an InGaN layer are combined, a GaN layer and an InGaN layer are combined, or an AlGaN layer and a GaN layer are combined, so that the layers are alternately stacked with the thickness of each layer set to tens to thousands of angstroms. In this case, the crystallizability of the current blocking layer 9 is improved. When the current blocking layer 9 having such a stacked structure is formed, the average refractive index in the current blocking layer 9 is set to be lower than the refractive index in the p-AlGaN cladding layer 7. Consequently, a semiconductor laser device 100 having a real refractive index guided structure is realized. Further, when the current blocking layer 9 includes an InGaN layer, the In composition of the InGaN layer is approximately the same as or not less than the In composition of the quantum well layer in the MQW light emitting layer 6. Consequently, light is absorbed in the current blocking layer, so that transverse mode control is carried out. Also in the current blocking layer 9 having such a stacked structure, the current blocking layer 9 is grown in the transverse direction on the SiO_2 film 30, thereby forming a current injection region having a width W_2. The substrate temperature in this case is set to 700 to

800°C at the time of growing the InGaN layer, while being set to 1000 to 1100°C at the time of growing the GaN layer and the AlGaN layer. When the current blocking layer 9 includes an AlGaN layer, it is preferable that the AlGaN layer is grown under reduced pressure.

[0055]

Although in the above-mentioned embodiment, description was made of a case where each of the layers 2 to 8 in the semiconductor laser device 100 is composed of a nitride semiconductor containing Ga, Al and In, each of the layers 2 to 8 may contain boron.

[0056]

Although in the method of fabricating the semiconductor laser device according to the present invention is particularly effective in a GaN based semiconductor laser device in which a p-type semiconductor layer has a high resistance, so that an injected current is injected into the p-type semiconductor layer below a current blocking layer without being widened, it is also applicable in a semiconductor laser device other than the GaN based semiconductor laser device, for example, a GaAs based semiconductor laser device.

[Brief Description of Drawing]

[Fig. 1]

A schematic sectional view showing an example of a GaN

based semiconductor laser device in an embodiment of the present invention.

[Fig. 2]

A diagram showing the ratio of the width of an upper surface of a ridge portion to the width of an opening of a current blocking layer and the coherence in the semiconductor laser device shown in Fig. 1.

[Fig. 3]

A schematic sectional view showing the steps of fabricating the semiconductor laser device shown in Fig. 1.

[Fig. 4]

A schematic sectional view showing the steps of fabricating the semiconductor laser device shown in Fig. 1.

[Fig. 5]

A schematic sectional view showing an example of a GaN based semiconductor laser device.

[Fig. 6]

A schematic sectional view showing an example of a semiconductor laser device having low-noise characteristics.

[Description of Reference Numerals]

1, 31: sapphire substrate

2, 32: AlGaN buffer layer

3, 33: GaN layer

4, 34: n-GaN layer

5, 35: n-AlGaN cladding layer

6, 36: MQW light emitting layer

7, 37: p-AlGaN cladding layer

8, 38: p-first GaN cap layer

9, 39: current blocking layer

10, 40: p-second GaN cap layer

20: saturable light absorbing region

30: SiO_2 film

50: n electrode

51: p electrode

100, 110, 120, 130: semiconductor laser device

[Document Name] Abstract

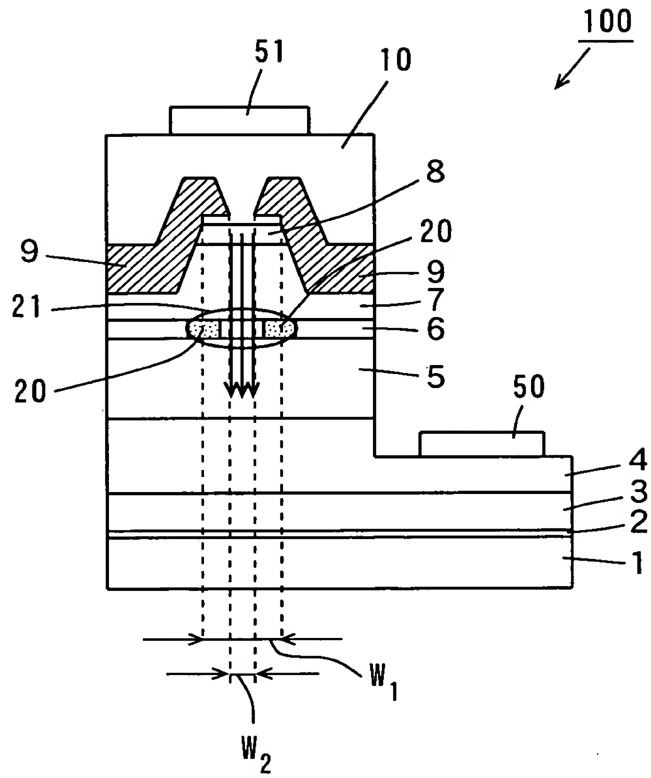
[Abstract]

[Subject] Providing a semiconductor laser device having low-noise characteristics which can easily be fabricated and a method of fabricating the same.

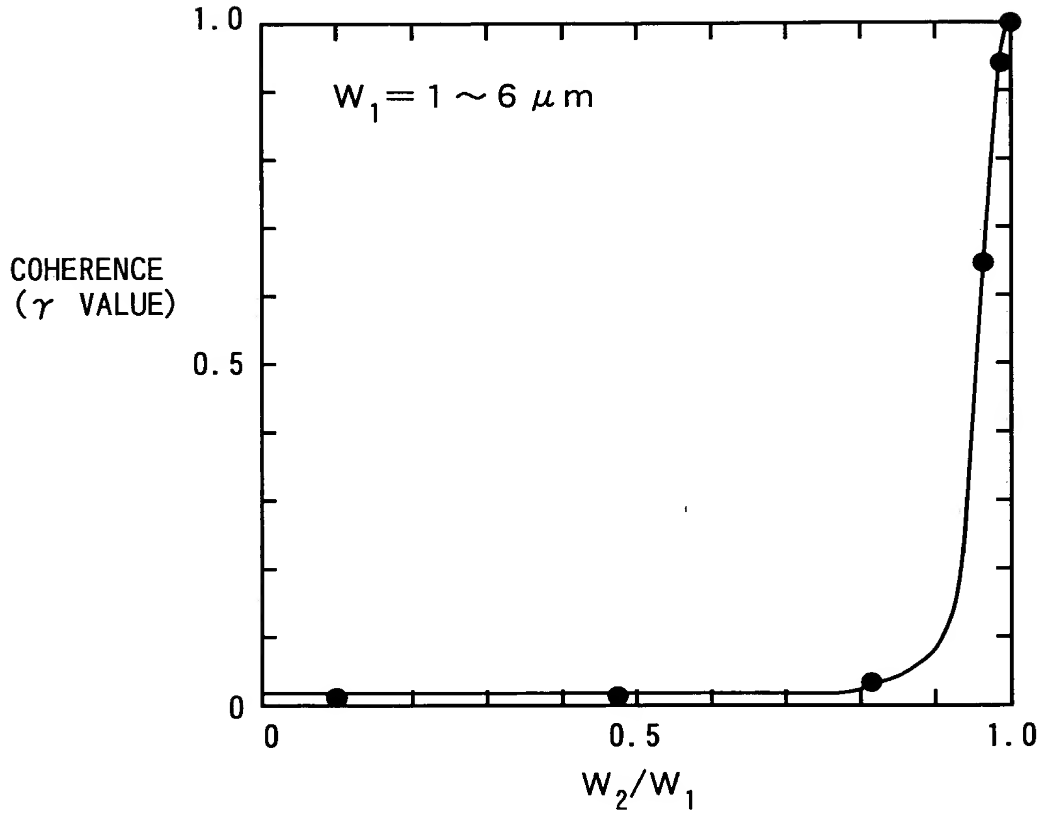
[Solving Means] In a semiconductor laser device 100, an AlGaN buffer layer 2, a GaN layer 3, an n-GaN layer 4, an n-AlGaN cladding layer 5, an MQW light emitting layer 6, a p-AlGaN cladding layer 7, a p-first GaN cap layer 8, a current blocking layer 9 composed of n-AlGaN, and a p-second GaN cap layer 10 are stacked in this order on a sapphire substrate 1, and a ridge portion having an upper surface of a width W_1 is formed by etching. The current blocking layer 9 has an opening of a width W_2 on the upper surface of the ridge portion. Since the width W_2 of the opening is smaller than the width W_1 of the upper surface of the ridge portion, a saturable light absorbing region 20 is formed on both sides of a current injection region in a light emitting region 21 of the MQW light emitting layer 6.

[Selected Drawing] Fig. 1

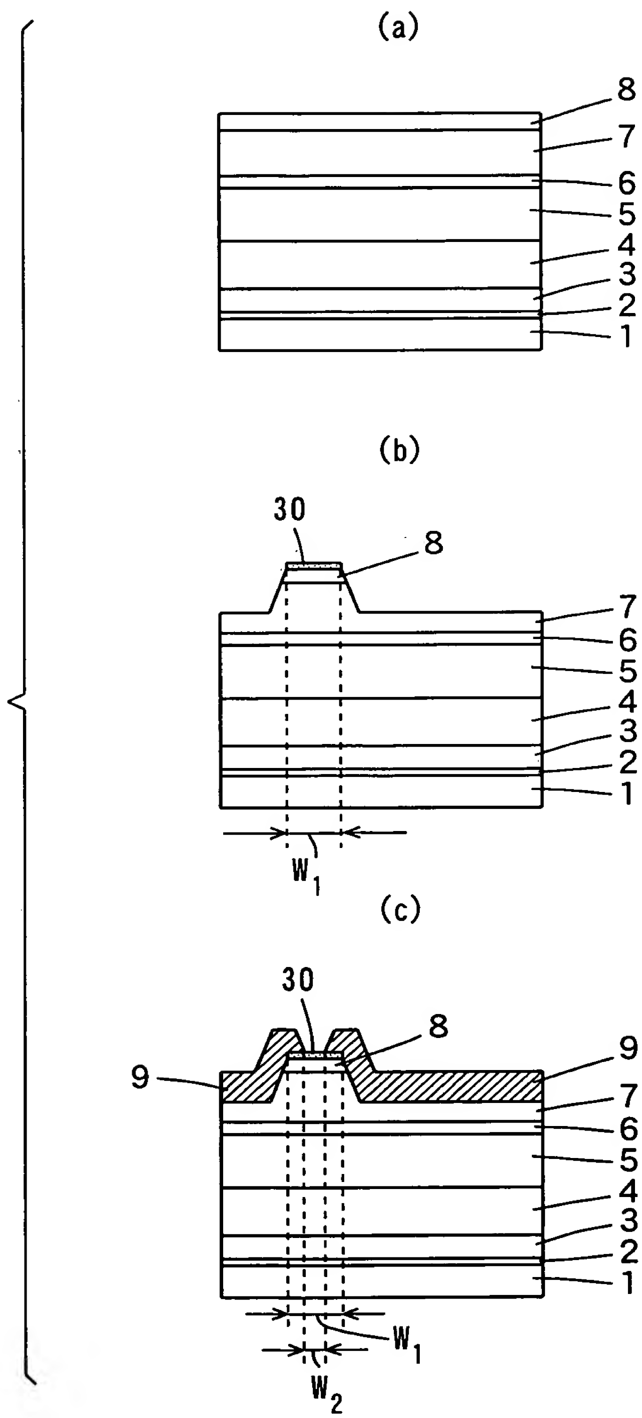
[FIG. 1]



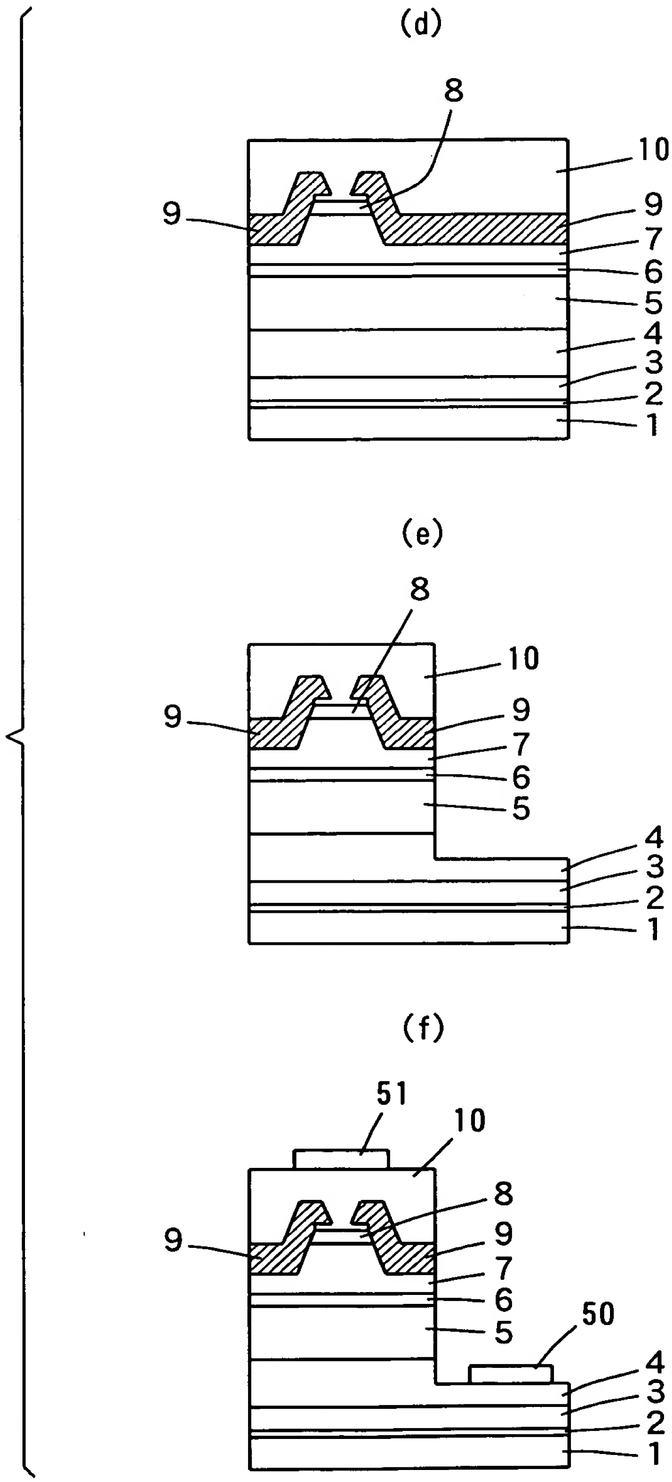
[FIG. 2]



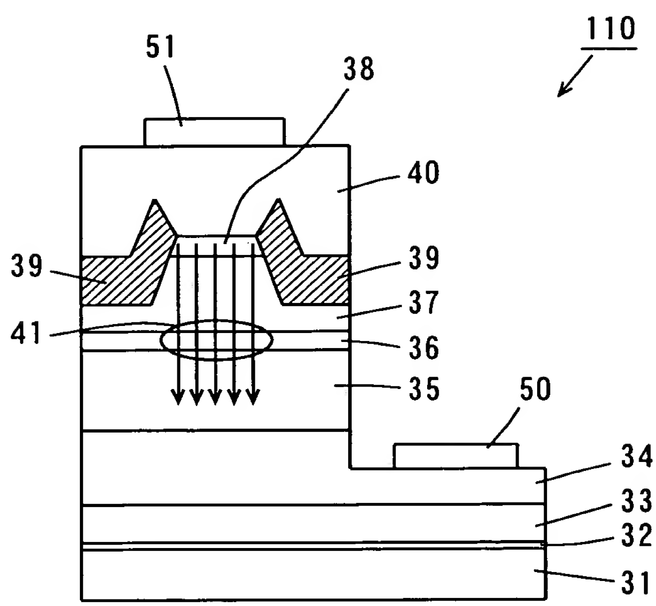
[FIG. 3]



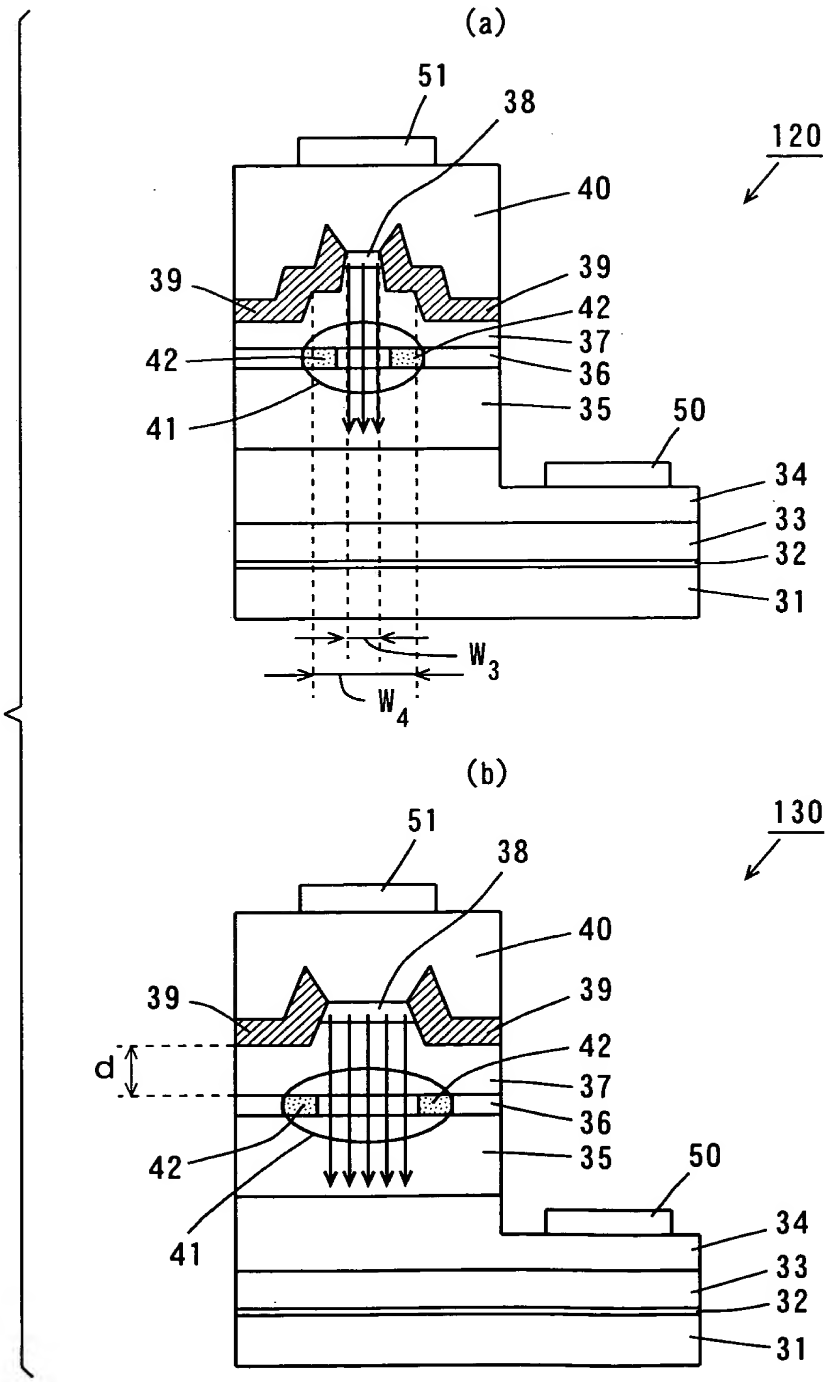
[FIG. 4]



[FIG. 5]



[FIG. 6]


(a)
51
38
120
40
39
39
42
37
42
36
35
41
50
34
33
32
31
W_3
W_4
(b)
130
51
38
40
39
39
42
d
37
36
42
35
50
41
34
33
32
31